

# Studies on Friction Stir Welding of Dissimilar Materials

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**Abstract**— Recently many reports on Friction Stir Welding (FSW) of various dissimilar systems such as Aluminium to Copper, Aluminium to Brass and Aluminium to Aluminium been reported. FSW of Aluminium, Copper and Brass has captured important attention from manufacturing industries, such as Shipbuilding, Automotive, Railway and Aircraft production. In FSW process, a so-called welding-head pin rotating at speeds usually in excess of a few hundred rpm, travels down the length of contacting metal plates, creating a highly plastically deformed zone through the associated force and frictional heating. Brass materials are widely used as engineering materials in industry because of their high electrical and thermal conductivity, high strength, and high corrosion resistance. Copper and its alloys are widely used in industrial applications due to their excellent electrical & thermal conductivities, good strength, corrosion & fatigue resistance. The aim of present study was analogy of the microstructures and mechanical properties of friction stir welded joint of Aluminium to Copper, Aluminium to Brass and Aluminium to Aluminium plates in 4mm thickness.

**Keywords**— Aluminium 6061, Pure Copper, Brass(CuZn30), Materials, Microstructure, Microhardness and Mechanical Properties, FSW.

## I. INTRODUCTION

Friction Stir Welding (FSW) is a unique welding method and new invention for the welding technology world. FSW will not change the microstructure of the metal diverse unlike the conventional welding. It also can reduce the cost if compared to the conventional welding cost. It involves the joining of metals without fusion or filler materials. It is used already in routine, as well as critical applications, for the joining of structural components made of Aluminium, Copper and Brass. Since FSW is essentially solid-state, i.e. without melting high quality weld can generally be fabricated with absence of solidification cracking, porosity, oxidation and other defects typical to traditional fusion welding. Friction stir welding was used to control properties in structural metals including aluminium and the other nonferrous

alloys. The pin may have a diameter one-third of the tapered tool shoulder.

In friction stir welding process a non consumable rotating tool with tapered pin and shoulder is inserted into abutting edges of plates. A non-consumable spinning tool bit is inserted into a work piece. The rotation of the tool creates friction that heats the material to a plastic state. As the tool traverses the weld joint, it extrudes material in a distinctive flow pattern and forges the material in its wake. The resulting solid phase bond joins the two pieces into one.

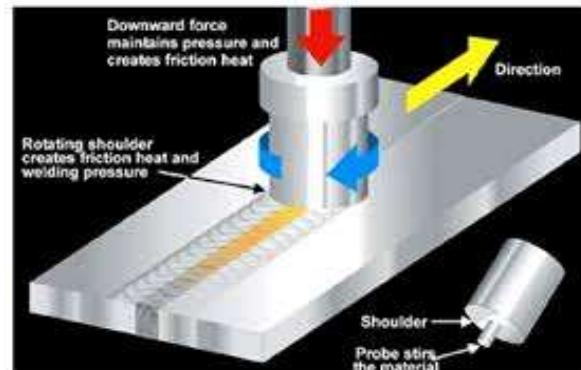


Fig.1: A Schematic Friction Stir Welding

## II. EXPERIMENTAL PROCEDURE

Vertical milling machine of 7Kw is used to join the dissimilar plates. The plate size of Al and pure copper are having 100mm length, 70mm width and 4mm thickness. Aluminium to Brass with dimensions (100mm x 70mm x 4mm) and Aluminium to Aluminium (100mm x 70mm x 4mm). In the present work H13 tool is used. The tool is having tapered shoulder and pin. For micro structural evaluation samples prepared by RAGHAVENDRA SPECTRO METALLRGICAL LABORATORY, Hyd and microstructure were measured on Optical Metallurgical Microscope (MET SCOPE-1). The micrographs were taken at 100x magnification. The Vickers micro hardness was measured by using HARDWOOD HWMMT-X7 micro hardness tester.

Table.1: H13 tool dimensions

Shoulder diameter(SD)	Pin diameter(PD)	Pin length (PL)
25mm	6mm	3.6mm

Table: 2 Chemical composition of 6061 Aluminium, Pure Copper and Brass (ZnCu30)

<b>6061 Al</b>	Si 0.80	Fe 0.70	Cu 0.40	Mn 0.15	Mg 1.2
	Cr 0.35	Zn 0.25	Ti 0.15	Al balance	
<b>Brass</b> Zn 30 Cu rest					
<b>Copper</b> Bi 0.001 O 0.04 Pb 0.0005 Cu rest					

Table.3: Process parameters

	Unit	Experiment 1	Experiment 2
Rotation Speed	Rpm	710 ,1120	710,1120
Transverse speed	mm/min	10-60	10-60
Offset	mm	1	1
Plunge depth	mm	3	3

After welding the specimens were prepared by using Wire EDM to test the mechanical properties such as ultimate tensile strength, yield strength, % elongation and Hardness. Tilt angle as 1 degree, offset were kept constant.

### Input Data

Material	Dissimilar and
Similar	
Thickness	4mm
Length	100mm
Width	70mm
Rotational Speed	710, and 1120 rpm
Feed	15-30 mm/min
Experiment 1	Aluminium to Copper
Experiment 2	Aluminium to Brass
Experiment 3	Aluminium to Aluminium

### III. RESULTS AND DISCUSSIONS

The following results were obtained after conducting the mechanical tests on FSW of Aluminium – Copper, Aluminium – Brass and Aluminium – Aluminium metals

#### 3.1 Output Data for Experiment 1 (710, & 1120 rpm)

For 710 rpm	Ultimate Tensile strength	37.69 N/mm <sup>2</sup>
	Yield Strength	29.808 N/mm <sup>2</sup>
	% Elongation	0.42%
For 1120 rpm	Ultimate Tensile strength	76.80 N/mm <sup>2</sup>
	Yield Strength	60.6 N/mm <sup>2</sup>

#### % Elongation 0.81% Output Data for Experiment 2 (710, & 1120 rpm)

For 710 rpm	Ultimate Tensile strength	73.15 N/mm <sup>2</sup>
	Yield Strength	55.118 N/mm <sup>2</sup>
	% Elongation	0.64%
For 1120 rpm	Ultimate Tensile strength	108.56 N/mm <sup>2</sup>
	Yield Strength	89.9 N/mm <sup>2</sup>
	% Elongation	0.98%

#### Output Data for Experiment 3 (710, & 1120 rpm)

For 710 rpm	Ultimate Tensile strength	140.46 N/mm <sup>2</sup>
	Yield Strength	115.32 N/mm <sup>2</sup>
	% Elongation	1.04 %
For 1120 rpm	Ultimate Tensile strength	240.78 N/mm <sup>2</sup>
	Yield Strength	215.54 N/mm <sup>2</sup>
	% Elongation	1.80 %

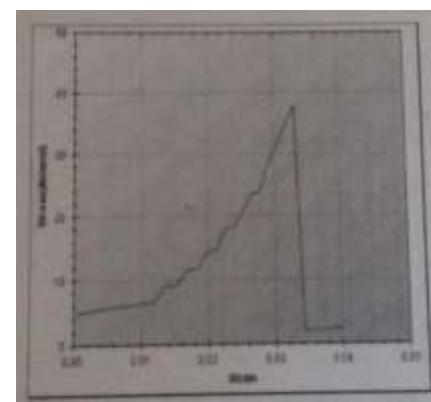


Fig.2: Graph for Al-Cu at 710 rpm

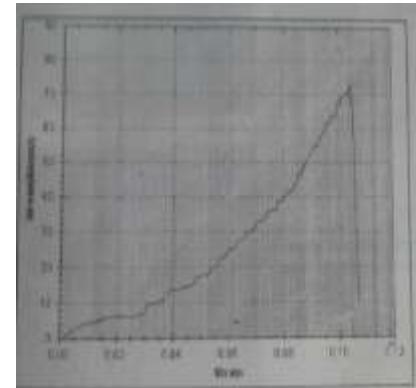


Fig.3: Graph for Al-Brass at 710 rpm

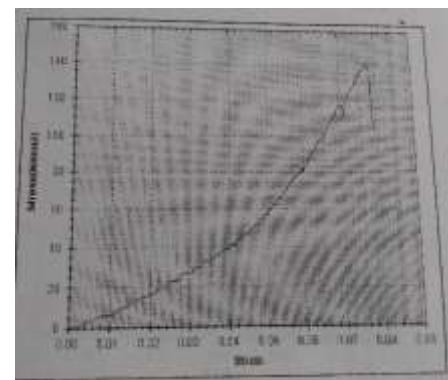


Fig.4: Graph for Al-Al at 710 rpm

### 3.2 Microstructure Analysis:

**For Experiment 1:** Microstructure of weld taken at centre of weld with or without filler materials. At the centre of weld a line mix region of aluminium and copper were found. Microstructure consists of uniformly distributed fine intermetallic particles in a matrix of aluminium solid solution. Cracks and porosity are seen. Lack of fusion more a length of the root.

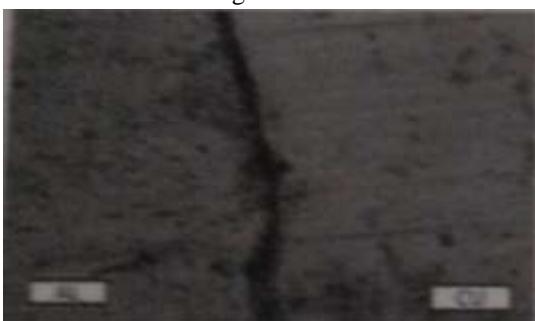


Fig:4: Microstructure Distribution at centre of Weld at 100x for 710rpm

**For Experiment 2:** The 100x magnification has been carried out at Centre of weld dendrites of brass solid solutions with fine particles of grains are seen. Blow holes and cracks are observed.



Fig.5: Microstructure Distribution at Center of Weld at 100x for 710 rpm

### For Experiment 3:

Dendrites of Aluminium solid solution with fine intermetallic particles and grains are seen. No blow holes and cracks observed at weld.

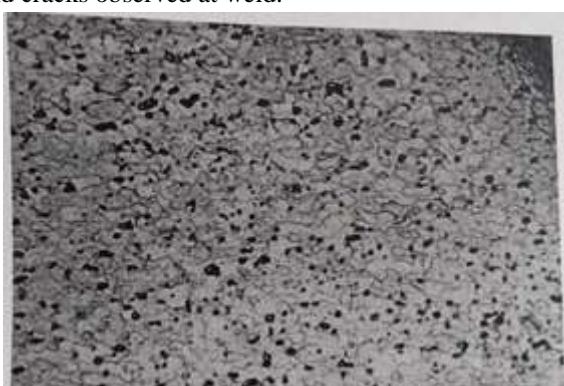


Fig.6: Microstructure Distribution Weld at 100x for 710 rpm

### 3.3 Microhardness:

The samples were polished using different size of emery paper and cloth polished also the Vicker's hardness of the final polished samples were measured by indentation test, with square base diamond base indenter which under the application of 5kg load with a dwell time of 10 sec. Then the diagonals of the indent formed on the material surface (Similar and Dissimilar) were measured.

#### For Experiment 1:

For 710 rpm	370HV
For 1120 rpm	440HV

#### For Experiment 2:

For 710 rpm	400HV
For 1120 rpm	510HV

#### For Experiment 3:

For 710 rpm	380HV
For 1120 rpm	490HV

## IV. CONCLUSION

Friction Stir Welding is performed to join 4mm thick plates of 6061 Aluminium to Pure Copper , Aluminium to brass (CuZn30) and Aluminium to Aluminium with varied parameters (like, tool rotation speed (rpm), welding speed (mm/min) and the joining conditions are characterized. All welds were defect free. Microstructure of weld and Microhardness were shown at centre of weld. Tensile strength was good. Aluminium - Aluminium has more strength comparative to Aluminium - Brass has high strength rather than Aluminium – copper.

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